Optimization of perfectly matched layers in electromagnetics using dolfin-adjoint

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Abstract

Electromagnetic wave propagation problems have been around for ever. Just over a century ago, man succeeded in describing the phenomenon by means of Maxwell's equations. Because of the complexity of the equations, studying the problem is challenging. In 1966 Yee introduced the first numerical scheme to numerically solve Maxwell's equation, based on finite differences. Which was the first widely used tool to study non-trivial electromagnetic problems. Later, other methods followed: the Finite Integration Technique, The Finite Element Method, The Finite Volume Method and more recently also Discontinuous Galerkin methods.
All these techniques suffer from the same problem: how can infinite physical domains, that occur in many (electromagnetic) wave propagation problems, be truncated to finite computational domains which are preferably as small as possible. Problems in which antenna's occur are just one example where infinite domains are required, e.g., a person using a mobile phone.
Many approaches have been proposed for truncating infinite domains. In 1994 Berenger introduced the, by far, most popular solution (so far) of Perfectly Matched Layers (PMLs). The main advantage of PMLs in comparison to it's predecessors such as absorbing boundary conditions or matched layers is the fact that a PML, in theory, is reflectionless for waves of every frequency and incidence angle.
The PML design parameters are nowadays still being chosen more or less by trial and error and rules of thumb, often limiting the number of control parameters. Dolfin-adjoint allows to to optimize the design parameters with minimal implementation effort and hence might be a powerful tool in PML design. In particular the use and description of the damping functions are under investigation.

The emphasis of the presentation will be on motivating the suggested approach, by sketching the history and current techniques. Also a problem-independent introduction to PMLs will be given. Finally some preliminary results obtained with dolfin-adjoint will be discussed.